MARQUETTE & GOUGLER

The Lay-Out and Equipment of a Locomotive Repair Shop

Railway Mechanical Engineering

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THE LAY-OUT AND EQUIPMENT OF A LOCOMOTIVE REPAIR SHOP

BY

HARRY ELLIS MARQUETTE
AND
JUDSON HENRY GOUGLER

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

JUDSON HENRY GOUGLER AND HARRY ELLIS MARQUETTE

ENTITLED THE LAY-OUT AND EQUIPMENT OF A LOCOMOTIVE REPAIR SHOP.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

RAILWAY MECHANICAL ENGINEERING

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THE LAY-OUT AND EQUIPMENT
OF A
LOCOMOTIVE REPAIR SHOP

I- INTRODUCTION

1. Statement of Problem- In this thesis it is proposed to layout a locomotive repair shop and select the equipment for it. The repair shop will be located at a locomotive terminal on a division of a railroad in the middle west. A few improvements will also be added to the locomotive terminal facilities.

2. Existing Conditions- The division which the shop is to serve consists of 250 miles of main line and a branch of 50 miles. The western part of the division contains many hills and curves, while the eastern part extends across prairie land. The track and bridges will not allow the use of locomotives much heavier than those on the division at present.

It is the policy of the railroad company to send only old locomotives to this division and use them here until they are worn out. The traffic throughout the year remains practically constant,and the demand for engines is always such that very little time is given to keeping them in good repair. Consequently the locomotives are subjected to the severest kind of service. The passenger engines make about 250 and the freight engines about 100 miles per day. Ordinarily the former class average 75,000 and the latter 50,000 miles between each general overhauling.The present assignment of locomotives to the division numbers about ninety.

The main locomotive repair shop for the railroad is located 260 miles from the proposed "division repair shop". The former is well equipped to take care of the more important repairs, such as new boilers and fireboxes. The proposed shop will therefore not be designed to make all classes of repairs,but only the lighter class,such as resetting flues,turning tires,and general repairs to machinery. This will thus relieve the main shop which at present,in attempting to do both classes of repairs,is overcrowded.

3. Land Available- The land available for the location of the repair shop is part of a tract of about four acres adjacent to the freight yards and main line track. Part of this land is already used for the present locomotive terminal and freight car repair tracks,the location of which is shown in Fig. 1, page 3. Many of the buildings are old frame structures. The elevation of the land affords good natural drainage.

4. General Considerations- In designing a locomotive repair shop it is necessary to allow for a probable yearly increase of equipment in order that the question of further extensions need not be considered for a period of from five to ten years after the new shop is in operation.

The division to be served by the proposed shop receives seven or eight engines per year. The shop should therefore be designed to provide for an increase of eight engines per year for a period of five years,that is,to care for forty in addition to the ninety in use at present,or a total of 130 engines.

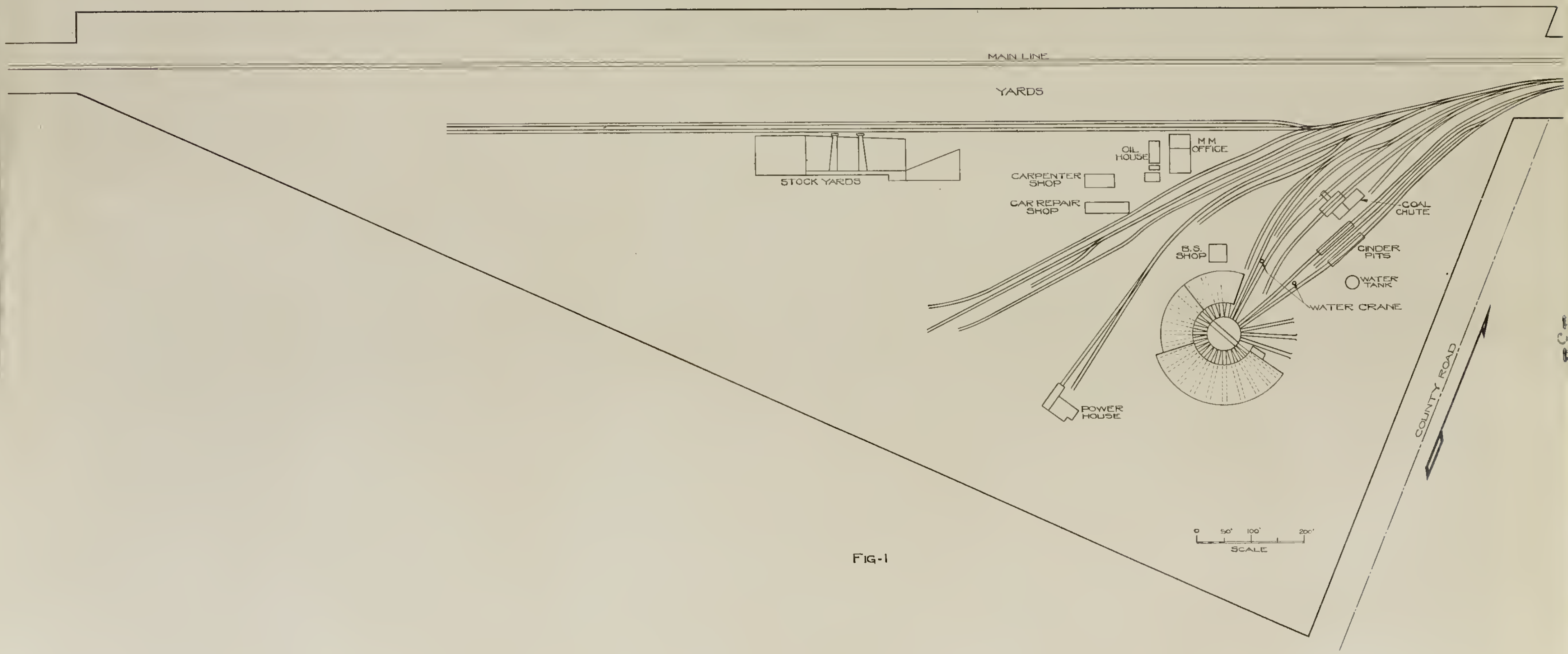

MAIN LINE
YARDS
STOCK YARDS
OIL HOUSE
M.M. OFFICE
CARPENTER SHOP
CAR REPAIR SHOP
COAL CHUTE
CINDER PITS
WATER TANK
WATER CRANE
B.S. SHOP
POWER HOUSE
COUNTY ROAD
0
50'
100'
200'
SCALE

FIG-1

Current practice indicates that a shop caring for the above number of engines requires about ten pits in the erecting shop. Referring to Fig.1 page 3,it is apparent that there are two possible layouts for a shop of this capacity;one wherein the erecting shop is entered by a yard approach,and another wherein it is entered by means of a transfer table. The question of longitudinal versus cross shop with large traversing crane does not enter into the selection of a shop of the above size since such arrangements are confined to larger erecting shops.

THE LAYOUT.

1. Various Departments of the Repair Shop- The principal departments for locomotive repairs are the erecting shop, machine shop,boiler shop,and blacksmith shop. These four shops form the main locomotive shop,and in the case under consideration will be grouped together in one building.

In addition to the above departments,the storehouse,toolroom,and general offices should be provided for. These sub-departments are closely associated with the main repair shop and will be given due consideration as to their size,location,and equipment.

2. The Erecting Shop- The erecting shop,the most important department and one upon which the size of the others depends,will be considered first.

Under present conditions the locomotives are in service about fifteen months between each general overhauling. The proposed shop is expected to give each engine light repairs once a year. The time an engine is to be held out of service for repairs has been assumed as thirty days. One pit in the erecting shop will therefore take care of twelve engines per year. Since 130 engines are to be repaired,eleven pits will be required. The average floor space per erecting pit of the shops listed in group 1,page 57; of Berg's American Railway Shop Systems, is 1570 square feet. Assuming this area per pit to be applicable in this case,the erecting shop shop should have a total

of 17270 square feet. Spacing the pits twenty-two feet centers fixes the length of the shop as 242 feet. To obtain the required floor area, the shop will be made 72 feet wide.

3. The Machine Shop- The machine shop is next in importance to the erecting shop and should be of sufficient size to accomodate all work required by the erecting department. According to Berg's American Railway Shop Systems, page 57 the machine shop should be about the same size as the erecting shop. The average square feet of floor space per erecting pit of the shops in group 1, is 1592 square feet or 22 square feet per erecting pit more than the erecting shop. Maintaining the same length as the erecting shop, namely 242 feet, the required area is obtained by making the machine shop 73 feet wide.

4. The Boiler and Tank Shop- One of the first points that should be considered after the size of the erecting and machine shops has been determined is the floor space required for the boiler shop.

Practice indicates that the size of the boiler shop bears a certain relation to the number of pits in the erecting shop. From Berg's American Railway Shop Systems,it has been found that the boiler shop should contain 715 square feet of floor space per erecting pit. A floor area of 7865 square feet will therefore be sufficient. In order to conform with the width of the erecting shop previously determined,the boiler shop will be made 72 feet wide, thereby fixing the length as 110 feet. This gives approximately the required floor area.

The work carried on in the boiler shop will consist of tank repairs,cutting flues,and laying out boiler plates.Boilers will not be carried into the boiler shop except for special work, but will be repaired in the erecting shop.This being so, one track in the boiler shop will probably be sufficient to take care of tank repairs.

5. The Blacksmith Shop- The next shop to be provided for is the blacksmith shop.The size of this,like that of the boiler shop,is dependent upon the number of erecting pits.According to standard practice, the number of square feet of floor space per erecting pit should be about 730. The blacksmith shop should therefore have a floor area of 8030 square feet. It is desirable to have the length of this shop equal to that of the boiler shop or 110 feet. With this dimension fixed a width of 73 feet will

furnish the required floor area.

6. The Storehouse- The storehouse will be made sufficiently large to contain the supplies for the round-house and the train and engine crews as well as the material for the locomotive repair shop. Since conditions vary at different shops there is no rule concerning the proper size of a storehouse. The best that can be done is to use the data obtained from investigating the sizes of storehouses located at shops having conditions similar to those of the proposed shop. After investigation, it is thought that a storehouse having a total area of 11000 square feet will be amply large. The storehouse will be built two stories high, for there is a large amount of small material that can be stored in the upper story. A platform elevator will be installed to convey the material from floor to floor. A portion of each floor will be used for offices of the mechanical and maintenance-of-way departments. The above named floor area is obtained by making the storehouse 100 feet long and 55 feet wide.

7. The Toolroom, Office, and Washroom- The toolroom should be of sufficient size to accomodate the tools and fixtures used in the various departments. It should also be large enough to contain the few machines used in keeping these tools and fixtures in proper working order. A toolroom 40 feet long and 25 feet wide seems adequate for the shop under consideration.

A washroom 30 feet long and 15 feet wide provided with lockers and toilet facilities will be located beside the toolroom.

The office of the shop foreman will be placed next to the toolroom and adjacent to the washroom. A hallway 3 feet wide, leading from the machine shop to the wash room will separate the office from the toolroom. The dimensions of the office will therefore be ten feet wide and 12 feet long.

8. Grouping of the Shops- In the design of a locomotive repair shop it is desirable to group the several departments under one roof,and to arrange them in such a manner that the different operations to be performed will follow in succesive order as material is moved from shop to shop. In this way useless travel of both men and material will be obviated.

The principles above stated may be readily applied to the design under consideration. The reasons for the relative locations of the different departments will now be explained.

From previous calculations it is evident that the main building should be 352 feet by 145 feet. The machine shop will be placed parallel to the erecting shop in the same building; thus making it possible to move the heavy parts of a locomotive, such as wheels,rods,and driving boxes,quickly and with a minimum amount of labor from one to the other.

The boiler shop is placed in line with the erecting shop, or is merely a continuation of it with a fire wall separating the two. This location of the boiler shop in relation to the erecting shop is desirable because the work carried on in the two is closely associated. Unnecessary expenditure of time and labor in transferring work from one to the other will be eliminated by having the two departments adjoining,thus permitting straight line movement of both men and material.

The blacksmith shop is situated in line with the machine shop and parallel to the boiler shop. This arrangement is advantageous because many of the parts to be repaired are taken directly from the erecting shop to the blacksmith shop,thence

to the machine shop and back to the erecting shop. Under the proposed arrangement these operations may be carried out in convenient order and with the least possible delay. Since the boiler shop will depend upon the blacksmith shop for small forgings,and the upsetting and heading of bolts, it will be convenient to have the two shops adjacent.

The ideal location for the toolroom might appear to be midway between the erecting shop and the machine shop. But in view of the fact that heavy machines will be placed near the erecting shop,and that these machines require very few tools from the toolroom,it is thought that less unproductive travel will result from locating the tool room,together with the wash room and foreman's office in a bay at the center of the longest wall of the machine shop.

9. Choice of the General Layout- As previously stated there are two feasible layouts for the proposed shop. The first layout to be considered is that whereby the locomotives may enter the erecting shop by means of a series of tracks and switches,in other words by a yard approach,as shown in Fig.2 (a) page 14. The second method to be considered is that in which the repair shop is served by a transfer table,as shown in Fig.2 (b) page 14. The purpose now is to enumerate the advantages or disadvantages of the two layouts and select the one which seems to present the more promising features.

With the location of the repair shop as shown in Fig.2 (a), the following unfavorable conditions seem to manifest themselves.

The storehouse cannot be located conveniently to both repair shop and round-house.

The repair shop is so remote from the round house that it would be necessary to add a small machine shop to the roundhouse for use in making "running" repairs to engines.

The layout as shown by Fig.2 (b), appears to have the following advantages.

It utilizes a tract of ground that otherwise might remain unserviceable.

The tract of ground left vacant by abandoning the yard approach may be used for a "Y" to turn engines in case the turntable is disabled.

Since the repair shop is near by,the roundhouse may depend upon the machine shop and blacksmith shop for the material

needed to make necessary "running" repairs to engines.

The transfer table is easily reached by incoming engines.

The storehouse may be located so as to be conveniently reached from both repair shop and round house.

Future extensions to all departments will be possible.

Appendix "A" page 40 states the probable costs of the two methods of entering the erecting shop,as described above. The figures indicate that a saving of $667.85 is realized by using the yard approach. It is considered that this slight difference in just cost is more than offset by the advantages stated above for layout"b",and it was therefore decided to adopt this layout,Fig.2 (b),whereby the erecting shop is entered by means of a transfer table.

10. Selected Shop and Locomotive Terminal Improvements-

The location of the locomotive repair shop having been selected, attention will now be given to a few of the minor details connected with it, and to some improvements to the locomotive terminal.

Fig. 3 page 16 shows the complete layout of the repair shop and the following terminal improvements.

The old power house will be enlarged;the northern half will be occupied by the boiler room and the other half by the engine room.

The scrap bins,blacksmith iron shed,and coal and coke bins will be located west of the boiler and blacksmith shops. They are served by a track from the round-house and yards connecting with the transfer table.

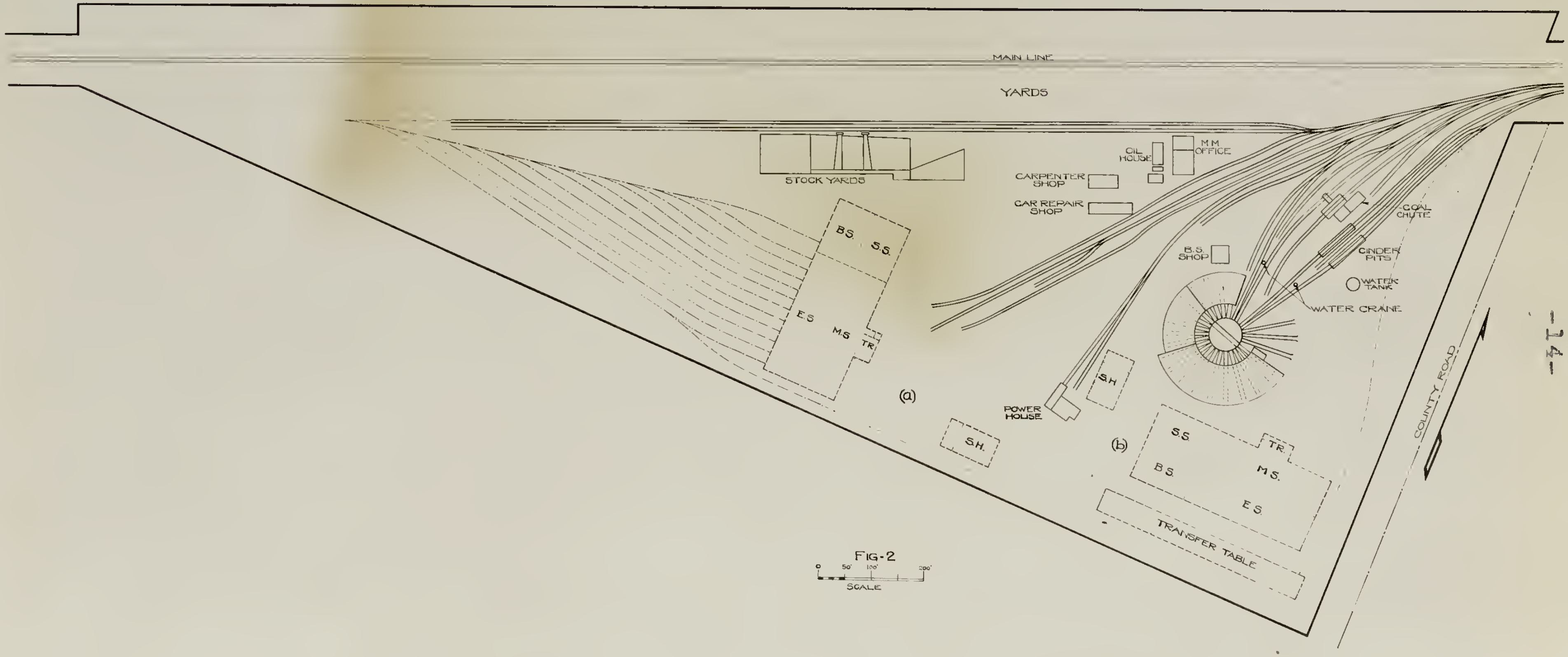

MAIN LINE
YARDS
STOCK YARDS
OIL HOUSE
M.M. OFFICE
CARPENTER SHOP
CAR REPAIR SHOP
COAL CHUTE
CINDER PITS
WATER TANK
WATER CRANE
B.S. SHOP
BS.
S.S.
E.S
M.S
TR.
(a)
S.H.
POWER HOUSE
S.H.
(b)
S.S.
TR.
B.S.
M.S.
E.S.
TRANSFER TABLE
COUNTY ROAD
0
50'
100'
200'
SCALE

FIG-2

The flue tumbler will be placed outside the boiler shop owing to the noise made by rattling the flues.

Lye vats for the cleaning of engine parts are to be placed on each side of the track leading from the yards to the east end of the transfer table. An overhead air hoist will serve each vat.

A large covered platform will be placed near the machine shop adjacent to the transfer table. This platform will be used for the storage of castings,springs,and driving wheel tires.

The improvements to the locomotive terminal will include a boiler washing system capable of washing twelve engines every twenty-four hours.

A track will be laid to connect the west end of the yards to the east end,so that engines may be taken to and from the round house without having to pass through the yards. This track will be most useful in cases of blockades,when under present conditions,long delays are often incurred in waiting to get an engine from one end of the yards to the other. A "Y" connection from this track will enable engines to be turned in case the turntable breaks down.

The oilhouse will be removed to a location nearer the tracks used by the out-bound engines.

The northern half of the round house will be enlarged to ninety ft. between the inner and outer walls. Three drop pits will be located in the other half of the round house. One of these pits will be used for engine trucks and the others for driving wheels. The center pit will connect with the erecting

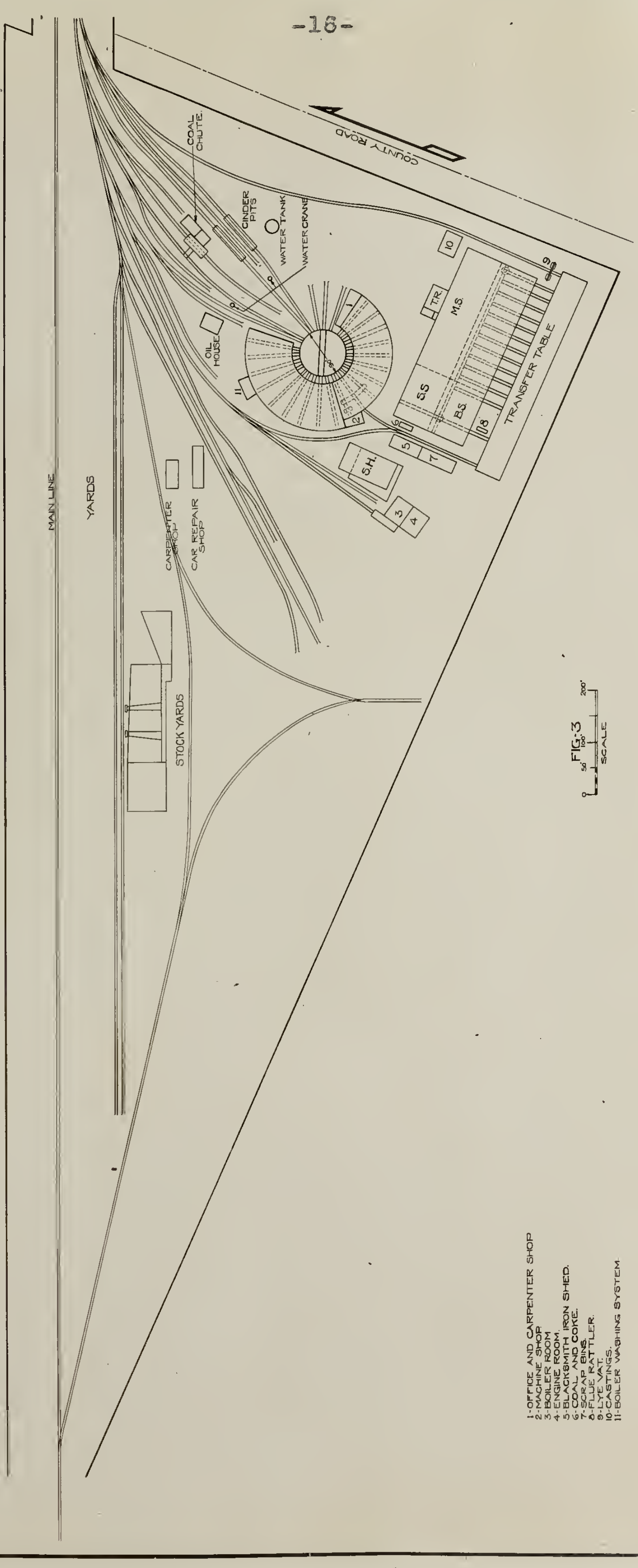


FIG. 3

1-OFFICE AND CARPENTER SHOP
2-MACHINE SHOP
3-BOILER ROOM
4-ENGINE ROOM.
5-BLACKSMITH IRON SHED.
6-COAL AND COKE.
7-SCRAP BINS.
8-FLUE RATTLER.
9-LYE VAT.
10-CASTINGS.
11-BOILER WASHING SYSTEM.

shop so that wheels may be transferred directly to the shop. A small building will be built at the junction of the two halves of the roundhouse, to be used as a small machine shop. This will be equipped with a 16-inch engine lathe, a 21-inch drill press, and a double emery wheel.

It seems advisable to have these machines near the drop pits in order to reduce unproductive travel between the roundhouse and repair shop.

The roundhouse foreman's office will be located in the addition built onto the southern half of the roundhouse. The other part of the addition will be occupied by a carpenter shop, for locomotive repairs.

The old 70 foot turntable will be replaced by a 90 foot turntable equipped with electric motors.

THE EQUIPMENT.

1. Erecting Shop Equipment- The equipment to be placed in the erecting shop will consist of apparatus for the unwheeling and wheeling of engines and a 10 ton crane having a span of 80 feet to be used in lifting and transferring the heavy parts of a locomotive. In large repair shops it is practicable to use a heavy overhead crane to unwheel the engines,but the shop under consideration is too small to warrant such a heavy crane. Two methods of unwheeling engines that are suitable in this shop are hoisting by hydraulic jacks or hoisting by an electric screw jack hoist. The latter method will be installed in this shop because it seems the more economical. Appendix "B" page 41 gives an outline of the cost of these two methods of hoisting locomotives.

The elcctric screw jack hoist,Fig.4 page 20 used for unwheeling engines will be placed over the first pit at the east end of the erecting shop. The center line of this pit is 13 feet from the wall and the other pits are spaced 22 feet from center to center. This leaves a space of 9 feet between the center line of the last pit and the fire wall separating the erecting and boiler shops.

The purpose is to bring an engine upon the pit equipped with the electric jack,unwheel the engine,place it upon trucks, and then move it out to the transfer table and thence to some other pit where the necessary repairs can be made.

It has been stated that eleven pits are required in the erecting shop. Since the electric jack is to occupy one of these pits continually,there are really only ten working pits, however since the unwheeling and rewheeling of engines will thereby be concentrated at one pit,these ten pits will be sufficient to take care of the engines undergoing repair.

Material racks for the storage of dismantled parts and work benches will be placed between each erecting pit.

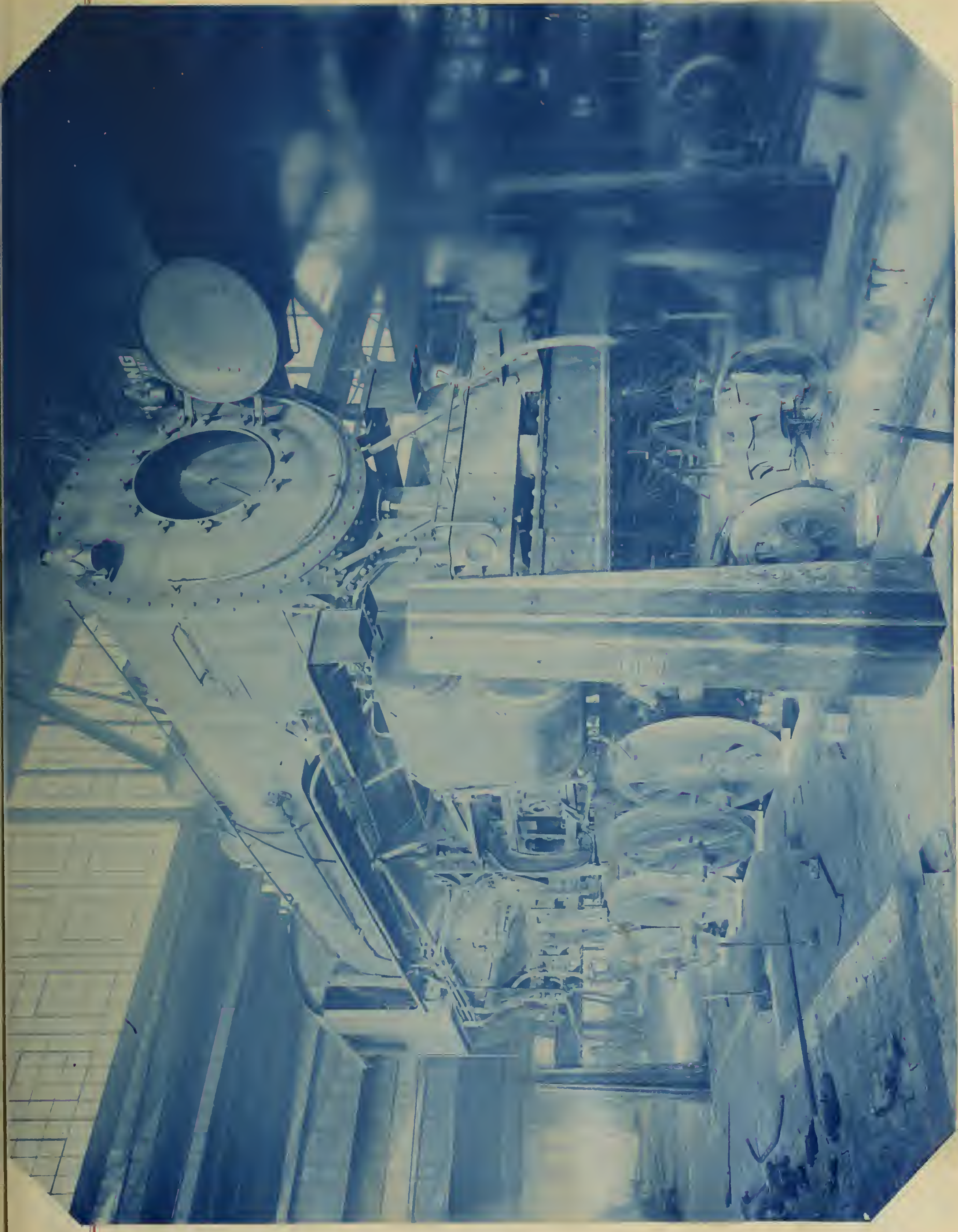


FIG 4

2. Selection of Machine Shop Equipment- The art of railway shop design has not yet been developed to the point where one can turn to accepted formulae for the selection of the equipment for the machine shop. The best that can be done is to follow what is thought to be good practice;but even then the solution is not easy,for the ratios deduced from the comparison of a number of shops are found to vary widely,and the figures thus obtained have to be modified by personal judgement.

It was at first thought possible to determine the equipment required for the machine shop by a graphical method,that is, by a series of curves showing the relation between the number of erecting pits and each class of machines in existing shops. But after obtaining many such relations it was found impossible to draw a curve that would in any way assist in determining the selection of the equipment. As shown in Fig.6 page 42,the scattered points indicate the number of four different kinds of machines in several shops of various sizes. This method was consequently abandoned.

The method adopted consisted of listing the size and number of the machines installed in seven shops each of about the same number of erecting pits as the proposed shop. These were tabulated as shown on pages 43 to 47,appendix "D". By taking an average of these,the equipment for the proposed shop was then selected. In some cases it was thought advisable to vary somewhat from the sizes thus determined. In cases where only the number of machines was given,the machines were listed in the

column "size not specified".

In order to determine how the equipment of the proposed shop compared with that of the other shops, the total number of machines in the seven shops was divided by the total number of erecting pits, or the "tools per pit" obtained. The number of "tools per pit" of the seven shops was 3.83 while the proposed shop has 3.73 "tools per pit". The proposed equipment evidently corresponds with usual practice.

PROPOSED SHOP.	TRUNK LINE SHOP.
Cutting Tools--17% of total.	Cutting Tools--26% of total.
Planers------43%	Planers------50%
Shapers------28%	Shapers------20%
Slotters----14%	Slotters----20%
Milling-----14%	Milling-----10%
Turning Tools--47% of total.	Turning Tools--52% of total.
Lathes-------84%	Lathes-------80%
Boring-------11%	Boring-------15%
Grinding---- 5%	Grinding---- 5%
Drilling--------12% of total.	Drilling--------13% of total.
Miscellaneous--24% of total.	Miscellaneous-- 9% of total.

The comparison of the proposed shop with the other shops by the above methods showed that a smaller number of machines is to be installed than is usually provided for a shop of its size. This is as it should be for the shop will not be required to work up to its full capacity for a period of five years and it seems preferable to add the machines as they are needed, rather than add them at first.

The machines will be group driven with the exception of a few of the larger machines which will be equipped with individual motors. The machines were selected from the latest catalogs. The list of tools for the machine shop is given on the following pages.

MACHINE SHOP EQUIPMENT.

Layout Number.	Number Required.	Description of Tools.	Maker.
37--38	2	Bolt Cutter, double Acme #2 Class "A".	Acme Machinery Co.
		BORING MACHINES.	
5	1	84" Bullard boring and turning mill. Motor drive.	Manning, Maxwell, & Moore.
6	1	51" Bullard boring and turning mill. Motor drive.	" " "
		DRILLING MACHINES.	
16	1	Radial drill, 72" Full Universal.	American Tool Wks Co.
13	1	Radial Drill. 30". High speed.	" " " "
10	1	28" Vertical Drill. Back geared, positive feed.	Manning, Maxwell, & Moore.
28	1	21" Vertical Drill. with tilting table.	" " "
34	1	15" Vertical Drill.	" " "
		GRINDING MACHINES.	
27	1	#2 Surface Grinder, Type "A".	Walker Grinder Co.
40	1	#0 Universal" Drill" Grinder. 1/8" to 2 1/2".	Universal Machine Co.
41	1	#3 Wet Tool Grinder.	" " "
8	1	Emery Wheel. 3" x 12".	Acme Mchy Co.
36	1	Emery Wheel. 4" x 24".	" " "
35	1	Grindstone. 8" x 48".	" " "

MACHINE SHOP EQUIPMENT. (continued)

Layout Number.	Number Required.	Description of Tools.	Maker.
		LATHES.	
1	1	84" Wheel Turning. Motor driven.	Wm. Sellers & Co.
7	1	42" Pond Engine, Triple geared head. Motor drive.	Niles-Bement-Pond. Co.
33	1	30" LeBlond Standard Engine. Double friction back geared.	LeBlond Mch Tool Co.
32	1	24" Pond Engine. Double back geared.	Niles-Bement-Pond.
12-24	2	18" American Engine. Double back geared.	American Tool Wks.
29-30	2	16" American Engine. Double Back geared.	" " "
19-20	2	14" American Engine. Double back geared.	" " "
39	1	14" American Engine. Tool room lathe.	" " "
26	1	12" LeBlond Engine. Quick change.	LeBlond Mch. Tool Co.
31	1	20" Automatic Brass and Turret Lathe.	Manning Maxwell & Moore.
25	1	#2 Centering Lathe. Capacity. 1/4" to 4 1/8".	" "
22	1	2 1/4" x 24" Turret.	LeBlond Mch. Tool Co.
21	1	1 1/2" x 18" Turret.	" " "
		MILLING MACHINES.	
18	1	#4 Universal.	Hendey Mch. Co.
23	1	Pipe Threading Machine. 1" to 4".	Acme Mchy. Co.

MACHINE SHOP EQUIPMENT.(continued)

Layout Number.	Number Required.	Description of Tools.	Maker.
		PLANERS.	
4	1	36" x 36" x 18'.Variable Speed.Motor drive.	Woodward & Powell.
3	1	30" x 30" x 14'.Variable Speed.Motor drive.	" "
17	1	24" x 24" x 8'.Variable Speed.Motor drive.	Cincinnati PlanerCo.
		PRESSES.	
11	1	50 Ton Hydraulic.	Railway Materials Co.
2	1	300 Ton Wheel. Motor drive.	" " "
		SHAPERS.	
9	1	24" Milwaukee. Back Geared Crank.	Lutter & Gies Co.
14	1	18" Ohio. Back Geared Crank.	Ohio Mch.Tool Co.
		SLOTTERS.	
15	1	18" Extra Heavy.Variable Speed.Motor drive.	Niles-Bement-Pond-Co.

4. Arrangement of Machine Shop Equipment- The various machines in the machine shop were arranged in so far as possible to fulfill the following requirements for the efficient handling of the work:to necessitate as little handling of material as possible,to group machines of like kind,to place heavy machines in such a way that they would be served by an overhead crane.

It is desirable to place the machines so that work will not have to be carried back and forth across the shop to complete the necessary operations. This not only saves time in getting out the required work,but also reduces unproductive travel. Grouping machines of like kind also reduces unproductive travel; the workmen know in what part of the shop,machines of this and that size are located and work may be left there for the machine that first becomes idle,grouping machines has the further advantage that good natured rivalry often results between men as to the amount of work they can accomplish. The advantage of placing heavy machines with a view to serving them by an overhead crane is obvious.

The arrangement of the machines in the machine shop is shown in Fig.5 page 28;their layout numbers are given on pages 29 to 30 and also in connection with the list of tools on pages 23 to 25.

It will be seen by referring to this figure that the machines required for the wheel work are grouped together and placed near the electric jack. They are also located beneath the overhead crane. This arrangement fulfills the three requirements for the efficient handling of all wheel work.

Near the wheel machines are located the machines for the driving box and rod work. Since the rods require considerable floor area and bench work it was thought advisable to reserve the space near the bench for them.

The central portion of the machine shop was left vacant in order to provide ample passageway from the erecting shop to the tool room and to leave room for the machines that will be added as the work of the shop increases.

The turret and engine lathes are grouped on the side of the shop adjacent to the blacksmith shop. It will be noticed that similar machines are placed side by side and that the larger machines are located around the edges of the group. Plenty of floor space has been alloted each machine in order that material may be stored near the machine and also leave the passageways open. The machines which are used quite often by the erecting shop men, such as grindstones, emerywheel, small drill press, and bolt cutter, are located close to the erecting shop.

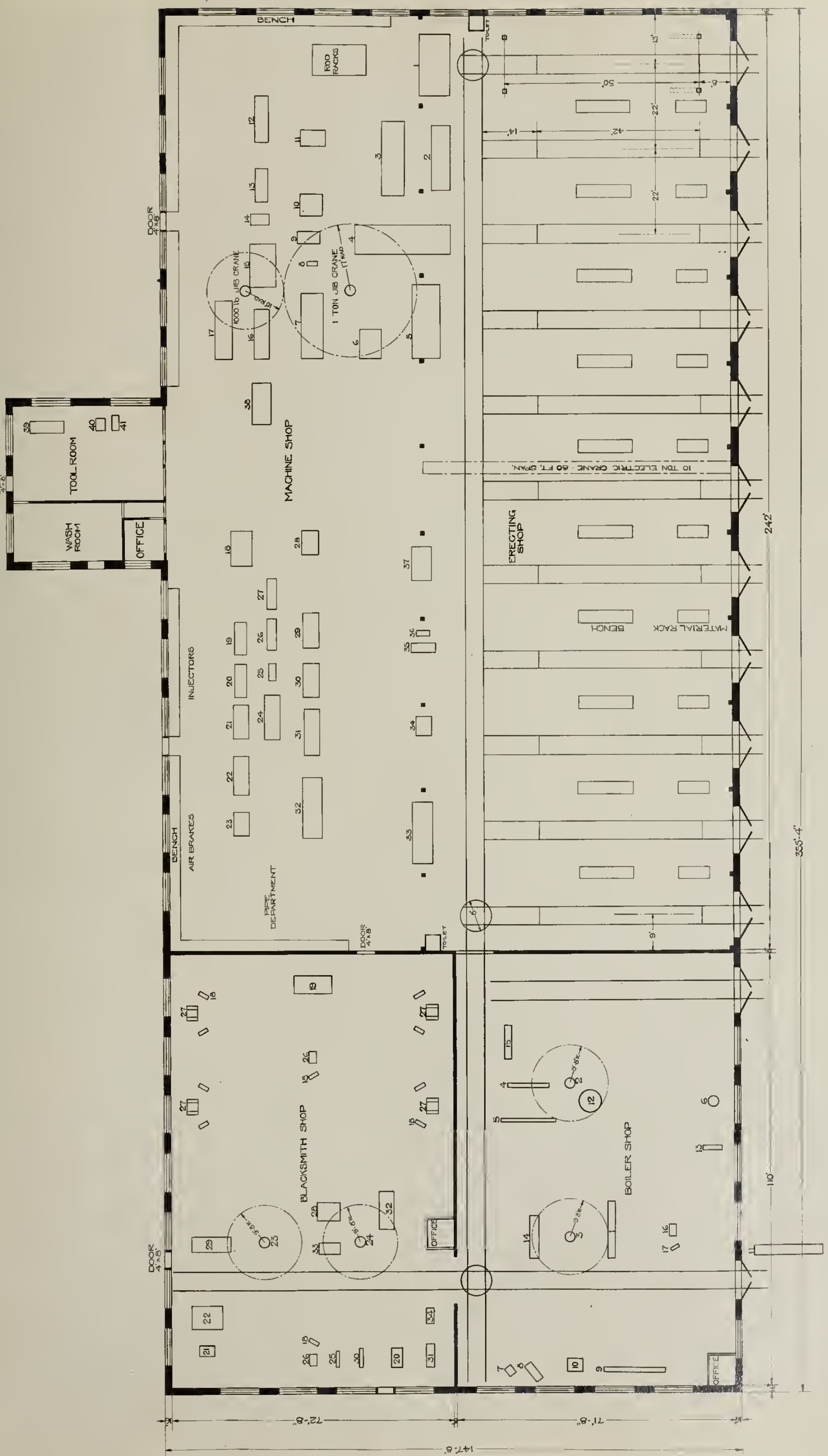

BENCH
ROD RACKS
DOOR 4'x8'
1000 lb JIB CRANE
1 TON JIB CRANE
DOOR 4'x6'
TOOL ROOM
WASH ROOM
OFFICE
MACHINE SHOP
INJECTORS
BENCH
AIR BRAKES
PIPE DEPARTMENT
TOILET
ERECTING SHOP
10 TON ELECTRIC CRANE - 80 FT. SPAN.
BENCH
MATERIAL RACK
BLACKSMITH SHOP
BOILER SHOP
OFFICE
50'
22'
14'
42'
13'
9'
242'
355'-4"
110'
72'-8"
71'-8"
147'-8"

FIG-5

MACHINE SHOP EQUIPMENT.

Layout Number.	Description of Tools.
1	84" Wheel Lathe.
2	300 Ton Wheel Press.
3	30" Planer.
4	36" Planer.
5	84" Boring Machine.
6	51" Boring Machine.
7	42" Lathe.
8	Emery Wheel.
9	24" Shaper.
10	28" Vertical Drill.
11	50 Ton Hydraulic Press.
12	18" Lathe.
13	30" Radial Drill.
14	18" Shaper.
15	18" Slotter.
16	72" Radial Drill.
17	24" Planer.
18	#4 Universal Milling Machine.
19	14" Lathe.
20	14" Lathe.
21	$1^1/_2$" x 18" Turret Lathe.
22	$2^1/_4$" x 24" Turret Lathe.
23	4" Pipe Threading Machine.
24	18" Lathe.
25	#2 Centering Lathe.
26	12" Le Blond Lathe.
27	#2 Surface Grinder.

MACHINE SHOP EQUIPMENT.(continued)

Layout Number.	Description of Tools.
28	21" Vertical Drill.
29	16" Lathe.
30	16" Lathe.
31	20" Automatic Brass Lathe.
32	24" Lathe.
33	30" Lathe.
34	15" Vertical Drill.
35	Grindstone.
36	Emery Wheel.
37	2" Double Bolt Cutter.
38	2" Double Bolt Cutter.
39	14" Lathe.
40	#0 Universal Drill Grinder.
41	#3 Wet Tool Grinder.

5. Selection of the Boiler and Blacksmith Shop Equipment.-

In selecting the tools of the boiler and blacksmith shops,the same general scheme was carried out that was used in selecting the machine shop equipment. Pages 48 to 51 appendix "E" and "F" give a list of the equipment in a number of shops of various sizes. From this the tools for the proposed shop were selected. Pages 32 and 33 give a list of the tools selected for the boiler and blacksmith shops respectively.

BOILER SHOP EQUIPMENT.

Layout Number	Number Required	Description of Tools	Maker
1	1	Bending Roll, Size "G". 12'-2" Belt Power.	New Doty Mfg. Co.
2	1	Crane, I Ton Hydraulic Pillar, Radius 9'-8"	Wm. Sellers & Co.
3	1	Crane, 2 Ton Hydraulic Pillar, Radius 9'-8"	Wm. Sellers & Co.
4	1	Clamp, 9' Hand.	Hilles & Jones Co.
5	1	Clamp, 12' Hydraulic.	Hilles & Jones Co.
6	1	Drill Press, 18".	Niles-Bement-Pond-Co.
7	1	Flue Welding Furnace for No. 8	Jos. T. Ryerson & Co.
8	1	Flue Welder	Jos. T. Ryerson & Co.
9	1	Flue Tester.	Railway Materials Co.
10	1	Flue Cutter.	Jos. T. Ryerson & Co.
11	1	Flue Rattler.	Jos. T. Ryerson & Co.
12	1	Forge for No. 4 and No. 5, Flanging.	Buffalo Forge Co.
13	1	Grindstone.	Acme Mchy. Co.
14	1	Punch and Shear, Size "A" 30" throats for 2" plate.	Long & Alstatter Co.
15	1	Stay Bolt Threader, Acme 1 1/2".	Acme Mchy. Co.
16	1	Forge	Buffalo Forge Co.
17	1	Anvil.	Buffalo Forge Co.

BLACKSMITH SHOP EQUIPMENT.

Layout Number	Number Required	Description of Tools.	Maker.
18	8	Anvils	Buffalo Forge Co.
19	1	Blower, No.8 Buffalo Steel Pressure.	Buffalo Forge Co.
20	1	Bulldozer,No.6	Acme Mchy. Co.
21	1	Bolt Furnace,for No.22.	National Mch.Co.
22	1	Bolt Header,Acme $1^1/_2$"	Acme Mchy.Co.
23	1	Crane,1 Ton Hydraulic Pillar,Radius 9'-8".	Wm.Sellers Co.
24	1	Crane,2 Ton Hydraulic Pillar,Radius 9'-8".	Wm.Sellers Co.
25	1	Emery Wheel	Acme Mchy.Co.
26	2	Forges, Single.	Buffalo Forge Co.
27	3	Forges,Double.	Buffalo Forge Co.
28	1	Forge,Frame for No.32.	Buffalo Forge Co.
29	1	Furnace,Open,for large work.	Railway Materials Co.
30	1	Grindstone.	Acme Mchy.Co.
31	1	Spring Furnace.	Railway Materials Co.
32	1	Steam Hammer, 1100 lbs. Double Frame.	Wm.Sellers Co.
33	1	Water Tank, Steel.	Railway Materials Co.
34	1	Punch and Shear, Hand Power.	Buffalo Forge Co.

6. Arrangement of Boiler Shop Equipment- Fig.5 page 28 shows the arrangement of tools,tracks,and turntable in the boiler shop. In this department the purpose was to place the tools in such a manner as to avoid handling material more than necessary, and to place machines for the heavier work in such a position that the least effort would be required in moving material to them.

The flue welding and cutting machines, for instance,are placed near the industrial track and at some distance from the other tools,since flue work will probably be done at different intervals on a large number of tubes. A considerable amount of floor space will therefore be required for storing flues and swinging them from the furnace to the welding and cutting machines. With the arrangement shown,it is believed that ample room has been provided,and that the work on the flues will not interfere with other work in the shop. Another example of arrangement may be cited. The bending roll and punch and shear are placed near the track,both being served by a two ton crane. With this arrangement boiler plate can be lifted from a car by the crane,passed through the bending roll,moved to the punch and shear by the crane,and thence back to the car.

The foreman's office is placed in the southwest corner of the shop. In this position the office does not occupy any "floor working" space and yet permits the foreman to see all work that is going on in the shop without leaving his office.

7. Arrangement of Blacksmith Shop Equipment- The arrangement of tools in the blacksmith shop is shown in Fig.5 page 28. In placing the tools in this department the same idea was carried out as in the boiler shop;the machines were arranged to carry on the work as conveniently as possible.

The spring tools are placed in the southwest corner of the shop near the industrial track and the emery wheel and grind stone are located in line with the bulldozer in order that all three machines can be driven by one motor. The bolt tools and furnace for large work are placed at the far end of the industrial track. The steam hammer,frame forge,and furnace are placed in the middle of the shop close to the track. All can be served by the two ton crane. Two double forges are placed at each side and a single forge at each end of the shop. A blower for furnishing air to the forges is located at the east end of the shop and will be driven by an individual motor.

The foreman's office is located adjacent to the south wall of the shop near the door which leads into the boiler shop. From this position the foreman can observe all work that is being carried on in the shop without leaving his office.

8. Structural Details and Auxiliary Features- Under this heading are included items that relate more closely to the building itself and which did not enter into other portions of the design.

The floor in the erecting and machine shops will be made of 6-inch gravel concrete, laid on a 12-inch bed of rolled cinders. The floor in the boiler and blacksmith shops will consist of a 12-inch layer of well tamped cinders. The pits in the erecting shop will be made 42 feet long and 26 inches deep. They will be faced with concrete and provided with compressed air, heat, and electricity.

A shop industrial track system will be installed, whereby material can be transported between the departments by means of push cars. The industrial track will extend the entire length of the erecting shop, (Fig.5) and will connect with the boiler and blacksmith shops. Three eight foot turntables will be used; one being placed in line with each end pit and the third at the junction of the boiler and blacksmith shop tracks.

The overhead steel structural work will consist of such trusses and frame work as is necessary to support the roof, motors for driving machines, pipes, lights, and wiring. Two rows of steel columns will support the track for the ten ton crane which serves the erecting shop. The roof will be of the saw-tooth type, the skylights being made of glazed wire glass fitted with proper apparatus for opening to allow ventilation.

All walls of the building will consist of brick 16-inches

thick,with the exception of the fire wall separating the different departments. This will be 8-inches in thickness. A heavy wire netting will separate the tool-room from the machine shop. Ten foot windows will be placed every five feet on all sides of the building except where it is necessary to place doors. Where tracks enter the building, 12 foot swinging doors will be located. All other doors will be made 4 feet by 8 feet.

The entire building will be heated by the Sturtevant hot blast system,hot air being delivered in two longitudinal underground conduits parallel to the side walls of the shop, with ducts leading to the surface about every 25 feet.

Artificial lighting will be accomplished by the use of Cooper-Hewitt lamps and in addition, single electric lights will be placed at each machine in the machine shop.

IV- ESTIMATE OF COST.

1- Cost of Buildings.		
Repair shop,352'x 145' at $1.90 per sq.ft.-------------	$97,000.00	
Tool room and wash room.---------	2,950.00	
Storehouse,100'x 55' at $1.50 per sq.ft.--------------	8,250.00	
	$108,200.00	$108,200.00
2- Cost of Repair Shop Equipment.		
Machine shop equipment, including shafting,motors, and 2 Jib Cranes.--------------	$53,600.00	
Boiler shop equipment.----------	7,310.00	
Blacksmith shop equipment.------	4,200.00	
10-Ton overhead crane.----------	4,275.00	
Electric Screw Jack Hoist.------	4,000.00	
	$73,385.00	$73,385.00
3- Cost of Auxiliary Equipment.		
Transfer Table.-----------------	$7,990.00	
Tracks and crane runway.--------	1,600.00	
Scrap bins,material sheds, and lye vats.------------------	1,700.00	
	$11,290.00	$11.290.00
Carried forward to page 39.---------------------------------		$192,875.00

Brought forward from page 38.		$192,875.00
4- Cost of Terminal Improvements.		
Oil house.	$2,000.00	
90 foot turntable.	8,000.00	
Drop pits.	1,000.00	
Round house enlargement.	1,900.00	
Machine shop equipment.	1,290.00	
Air and steam pipe lines.	450.00	
2 Tank boiler washing system.	11,000.00	
"Y" Track.	2,800.00	
	$28,440.00	$28,440.00
TOTAL COST.		$221,315.00

-APPENDIX-

"A". Cost of Yard Approach, Transfer Table, etc- The following is a statement of the probable cost of the two methods of entering the erecting shop.

Yard Approach.

16064 feet of second hand 60# rails at $20. per ton.	$3212.80
4016 second hand ties at 30¢ per tie.	1204.00
244 joints, complete at $1.10 per joint.	268.00
13 #15 switch points at $17.50 per switch.	227.50
13 #7 frogs at $15.00 per frog.	195.00
13 "ground" switches at $4.25 each.	55.25
12375 lbs. spikes at 2.25¢ per pound.	278.45
Laying 8032 feet of track and surfacing at $350.00 per mile.	532.00
Probable cost of small machine shop. 25'x 30' annexed to round-house.	1350.00
	$7323.00

Transfer Table, etc.

Price of 50 foot transfer table, not including rails and excavation.	$5500.00
Excavating 1480 cu.yds. at 35¢ per cu.yd.	518.00
2865 feet of second hand 60# rails at $20. per ton.	573.00
40 joints, complete at $1.10 per joint.	44.00
715 second hand ties at 30¢ per tie.	214.00
2250 lbs. of spikes at 2.25¢ per pound.	50.60
1 #15 switch point.	17.50
1 #7 frog.	15.00
1 "ground" switch.	4.25
240 cu.yds concrete work at $4.00 per cu.yd.	960.00
Laying 1432 feet of track and surfacing, $350. per mile.	94.50
	$7990.85

"B". Comparison of the Cost of Two Methods of Unwheeling an Engine- The following statements and figures explain the probable cost of two methods of unwheeling a locomotive. Interest and depreciation losses are not included.

1 Electric Screw Jack Hoist,complete.---------------- $4000.00

With an electric hoist one man can hoist an engine in a very short time;hence the cost of labor is practicably negligible.

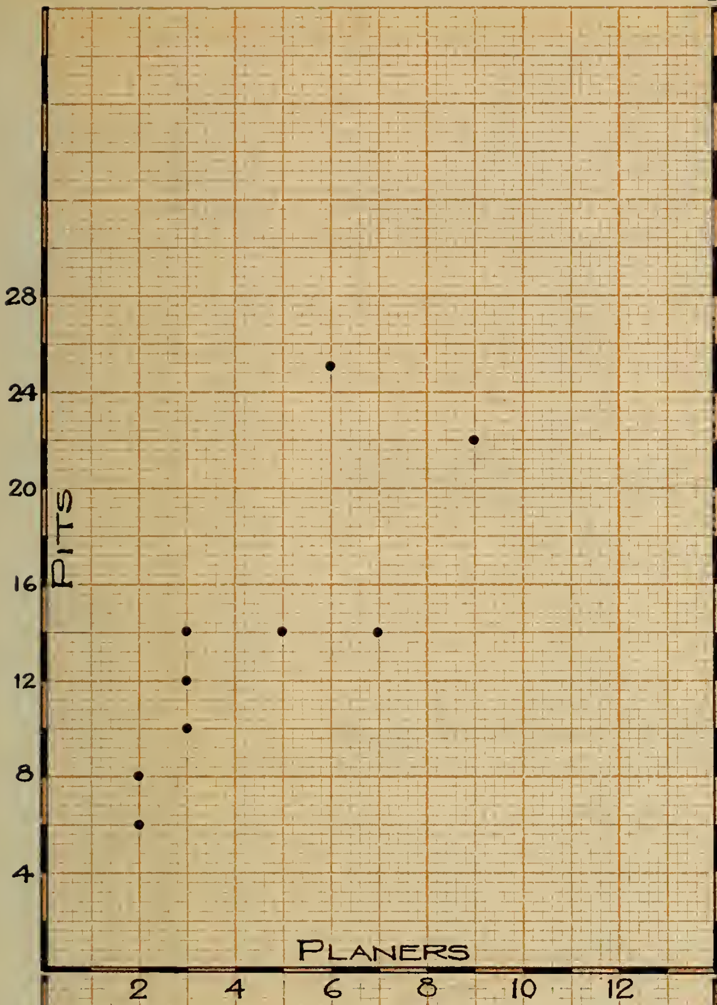
4 Hydraulic Jacks, at $140.00 each.------ $560.00

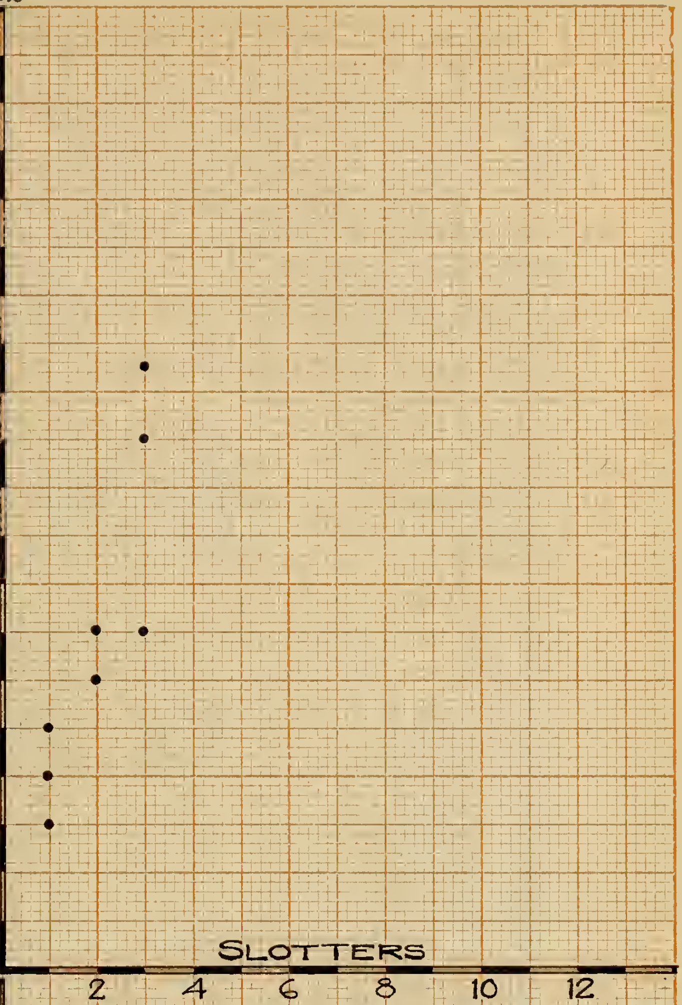
Two machinists and four helpers can "jack-up" an engine in ten hours. The cost of this class of labor per ten hours is $16.00. 12 engines will be "jacked-up" every month.

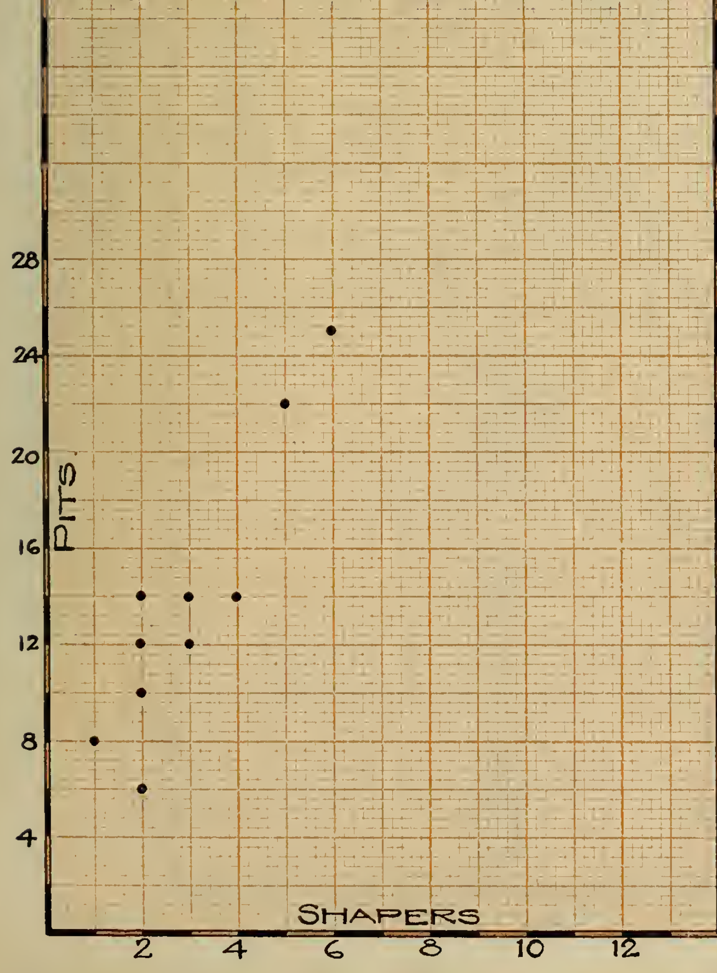
Cost of labor for 18 months.------------- $3456.00

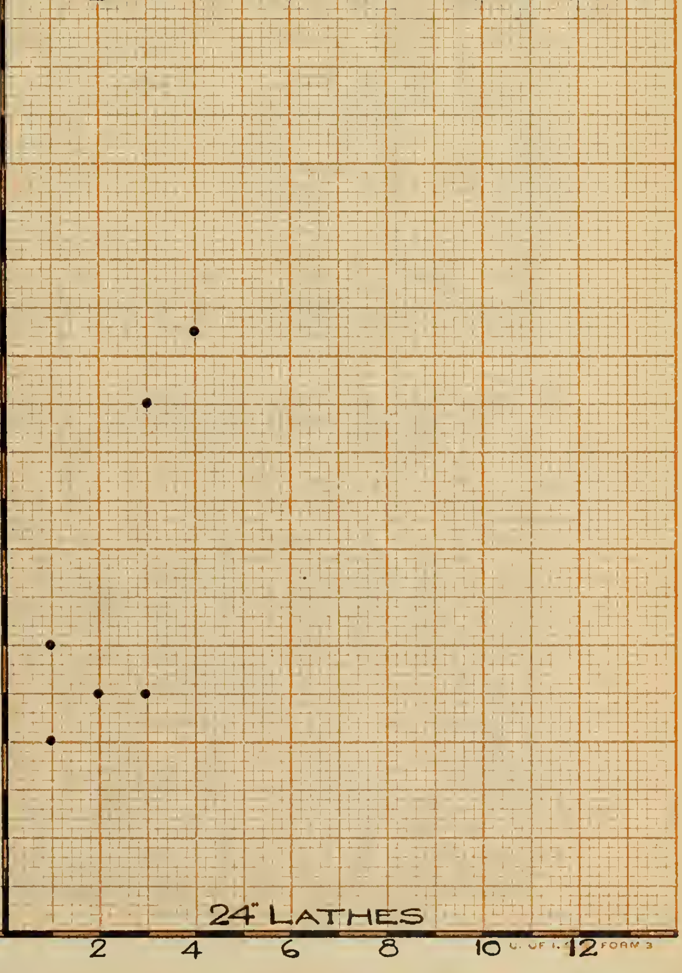
$4016.00 $4000.00

From the above figures it will be noticed that although the first cost of hydraulic jacks is very much less than that of an electric screw jack hoist;the money expended for labor in eighteen months in "jacking-up" a locomotive,plus the price of four hydraulic jacks would be sufficient to pay for an electric screw jack hoist.


28
24
20
Pits
16
12
8
4
Planers
2
4
6
8
10
12


Slotters
2
4
6
8
10
12


28
24
20
Pits
16
12
8
4
Shapers
2
4
6
8
10
12


24" Lathes
2
4
6
8
10
12

EQUIPMENT OF VARIOUS MACHINE SHOPS

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Planers								Shapers				Slotters				Milling Machines		
			Size not specified	54"x54"x20'	42"x42"	36"x36"	32"x32"	30"x30"	26"x26"	24"x24"	Size not specified	24"	20"	18"	Size not specified	22"	18"	15"	Size not specified	#4 Universal	#3 LeBlond
CB&Q	Hannibal	10		1	1			1			2							1	1		
CCC&St.L	Urbana	10					1	1	1			1			1				2		
C & NW	Boone	12				2				1	3				1						
B & M	Concord	12	7								2				3				1		
So.Pac.	Empalme	12		1		1			1			1	1			1		1	1	1	
EP&SW	ElPaso	14				1	1					2					1				1
PENN	DuBois	14	1			1			3	1	2						1		2		
PROPOSED SHOP		11				1		1		1		1		1			1			1	

EQUIPMENT OF VARIOUS MACHINE SHOPS (continued)

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Wheel Lathes				Engine Lathes														
			Size not specified	90"	89"	79"	Size not specified	48"	42"	40"	38"	36"	30"	28"	26"	24"	20"	18"	16"	14"	12"
CB&Q	Hannibal	10	1					1		1			3			2	1	2		4	
CCC&StL	Urbana	10	2				1		1	1				1		3		1		5	1
C&NW	Boone	12	2						1	1	1				1	1		4	2		
B & M	Concord	12	3				16													1	
So.Pac.	Empalme	12		1								1	2			1	1		5		1
EP&SW	El Paso	14			1	1	1		1					1		1		2	1	1	
PENN	Dubois	14				2	1		1					1		1		3	5		
PROPOSED SHOP		11			1				1				1			1		2	2	3	1

EQUIPMENT OF VARIOUS MACHINE SHOPS (continued)

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Turret Lathes									Miscellaneous Lathes									
			Size not specified	6 1/2" x 24"	6"	3" x 36"	2 1/4" x 24"	2" x 26"	18"	16"	1 1/2" x 18"	Buffing	Centering	Speed	20" Brass	18" Brass	Car Wheel	Journal	Quartering Machine	Slab Milling Machine	Pipe Threading Machine
CB&Q	Hannibal	10	1										1		1	1		1			
CCC&St.L	Urbana	10	2										1								
C & NW	Boone	12																			
B & M.	Concord	12	1										1	2	2		5				
So.Pac.	Empalme	12			1	1		1	1	1			1		1	1			1		
EP&SW	ElPaso	14		1			1					1	1		1	1				1	1
PENN	Dubois	14					1		2								1	2	1		2
PROPOSED SHOP		11					1				1		1		1						1

EQUIPMENT OF VARIOUS MACHINE SHOPS (continued)

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Horizontal Boring Mills				Vertical Boring Mills				Radial Drills					Vertical Drills					
			Size not specified	62"	42"	#3 Bement	Size not specified	84"	51"	42"	Size not specified	72"	66"	60"	30"	Size not specified	32"	28"	24"	21"	15"
CB&Q	Hannibal	10									1					5					
CCC&StL	Urbana	10	1								3					1					1
C & NW	Boone	12							1		1					2					
B & M	Concord	12					2				1					4					
So.Pac.	Empalme	12		1	1			1	1			1			2			1			1
EP&SW	El Paso	14				1		1		1			1	1		2					
PENN	Dubois	14	1				1	1	1			2					1	2	2	1	
PROPOSED SHOP		11						1	1			1			1			1		1	1

EQUIPMENT OF VARIOUS MACHINE SHOPS (continued)

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Guide Grinders	Link Grinders	Drill Grinders	Tool Grinders	Grinding Machines	Grindstones	Emery Wheels	Car brass Borer	Car wheel Borer	Car wheel Press	Driving wheel Press	Screw Press	Nut Tapper	Triple Bolt Cutter	Double Bolt Cutter	Single Bolt Cutter	Die Sinking Machine	Stay Bolt Machine	Key Seating Machine
CB&Q	Hannibal	10	1	1	1		1	2	1	1	1	1			1		2	1			
CCC&StL	Urbana	10			1	1		1	1				1				1	1			
C&NW	Boone	12							3				1	1			2				
B & M	Concord	12			1		3					1	1		1		2				
So.Pac.	Empalme	12			1		2	1	2				1						1	1	1
EP&SW	El Paso	14	1		1	2		1	2				1			1					
PENN.	Dubois	14			1	5	2				1		1				1				
PROPOSED SHOP		11			1	1	1	1	2				1				2				

EQUIPMENT OF VARIOUS BOILER SHOPS

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Bending Rolls (6')	Bending Rolls (12')	Blower (#5)	Bevel Shears	Crane (1 Ton)	Crane (2 Ton)	Clamps	Drill Press	Emery Wheel	Flange Punch	Flanging Block	Flue Cutter	Flue Welder	Flue Tester
CB&Q	Hannibal	10		1			1							1	1	
CCC&StL	Urbana	10		1			1	1	2			1		1	1	1
C&NW	Boone	12								1	1			1		
B & M	Concord	12		1			1		1	1		1	1	1	1	1
So.Pac.	Empalme	12	1	1		1		1								
EP&SW	ElPaso	14		1				1							2	1
PENN.	Dubois	14		1	1			1	2	1	1	1		2	1	1
PROPOSED SHOP		11		1			1	1	2	1				1	1	1

EQUIPMENT OF VARIOUS BOILER SHOPS (Continued)

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Flue Welding Furnace	Flue Tumbler	Furnace	Flanging Forge	Grindstone	Plate Planer (20')	Punching Machine	Punch & Shear	Radial Drill Press	Staybolt Threader	Staybolt Cutter	Shearing Machine	Splitting Shear	Sheet Rolls
CB&Q	Hannibal	10		1		1			1	1						1
CCC&StL	Urbana	10	1		2					1						
C&NW	Boone	12	1		1		1			1				1		
B & M	Concord	12	1			1		1	1		1			1		
So.Pac.	Empalme	12				1			1	2	1	1			1	
EP&SW	El Paso	14		1							1	1				
PENN.	Dubois	14		1	1			1		1	1		1			1
PROPOSED SHOP		11	1	1		1	1			1		1				

EQUIPMENT OF VARIOUS BLACKSMITH SHOPS.

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Blower (#8)	Blower (#9)	Bulldozer (#6)	Bolt Header	Bolt Shear	Bolt Furnace	Crane (1 Ton)	Crane (2 Ton)	Crane (5 Ton)	Drill Press (30")	Emery Wheel	Forges	Frame Forge	Flange Forge	Furnace	Forging Machine
CB&Q	Hannibal	10				1	1		2	2				11			1	
CCC&StL	Urbana	10	1		1	1		1	2	1				8	1			1
C&NW	Boone	12		1	1								1	10	1		1	
B & M	Concord	12	1			1	1					1		20	1			
So.Pac.	Empalme	12	1		1					2	3			24			1	
EP&SW	ElPaso	14	1		1				1	2				14				1
PENN.	Dubois	14				1		1	3	3		1	1	10	3	1	1	
PROPOSED SHOP		11	1		1	1		1	2	1			1	8	1		1	

EQUIPMENT OF VARIOUS BLACKSMITH SHOPS (continued)

RAILROAD COMPANY	LOCATION OF SHOP	PITS IN ERECTING SHOP	Grind Stone	Oil Furnace	Punch and Shears	Spring Furnace	Scrap Furnace	Steam Hammer (80#)	Steam Hammer (200#)	Steam Hammer(500#)	Steam Hammer (800#)	Steam Hammer (1000#)	Steam Hammer (1500#)	Steam Hammer (1800#)	Steam Hammer (3000#)	Steam Hammer (4000#)	Water Tank	Cutting Off Saw
CB&Q	Hannibal	10	1	1	1	1				1	1	1					2	
CCC&St.L.	Urbana	10	1	1	1	1						1					1	
C&NW	Boone	12	1									1						
B&M	Concord	12							1	1		1		1				
So.Pac.	Empalme	12							1			1	1			1		
EP&SW	ElPaso	14			1	1	1		1			1	1					
PENN.	Dubois	14			1	1	1	1			1				1			1
PROPOSED SHOP		11	1			1						1					1	

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